International Journal of Agricultural Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 7, Issue 2, Apr 2017, 81-86

TRANS STELLAR
•Journal Publications •Research Consultancy

COMPARATIVE ANALYSIS OF TRADITIONAL AND MODERN METHODS OF *Aonla* PRICKING: A TECHNO-ECONOMIC AND ERGONOMIC ASSESSMENT

NITIN KUMAR, KIRANDEEP, ANKIT KUMAR & A. N. MALATHI

Department of Processing and Food Engineering, COAE&T, PAU, Ludhiana, Punjab, India

ABSTRACT

Studies were carried out to compare the traditional and modern methods of fruit pricking in which aonlas were pricked by using fork, pricking tool and a hand operated aonla pricking machine with the help of four different healthy individuals falling in the age group of 25-35 years. The anthropometric data of the subjects was collected. The capacity and performance of all the three methods were thus calculated. The ergonomics of the machine was also studied for which different parameters like heart rate, energy expenditure, physiological workload, grip fatigue & blood pressure were evaluated for different individuals during the three pricking activities. It was found that the physiological workload and blood pressure fluctuations of the individuals working on the hand operated aonla pricking machine were less as compared to the other two methods of pricking. The energy requirements came out to be almost equal in all the three methods of pricking. The cost of operation of the machine was also calculated. The quality of pricking in aonlas done by the hand operated aonla pricking machine was found out to be better than the other two methods which made it economically as well as technically feasible for use.

KEYWORDS: Aonla, Pricking, Machine, Ergonomics & Comparison

Received: Jan 10, 2017; **Accepted:** Feb 19, 2017; **Published:** Feb 22, 2017; **Paper Id.:** IJASRAPR201712

Original Article

INTRODUCTION

Aonla, popularly known as the Indian gooseberry, (Emblica Officinalis Garten.) is one of the most important, indigenous fruit of India. The fresh fruits are generally not consumed due to their high astringency but it has got great potential in processed forms hence been focused on the preparation of different value added products. *Aonla* preserve is a popular traditional product but lack of scientific approach in its pricking, preparation and preservation renders this valuable product vulnerable to spoilage in a short period of time after its preparation.

Ergonomics is the scientific study of the interaction between men and their work environment. Application of ergonomics helps to design an equipment to get enhanced efficiency of the human workers without jeopardizing their health and safety. Proper ergonomic design is necessary to prevent repetitive strain injuries, which can develop over time and can lead to long-term disability (Bressel *etal*., 2001). In India, greater part of the population works on farms and they still use the outdated methods, which depend on human muscle power. These traditional methods of pricking employing the use of manual tools are tiresome, time consuming and unhygienic. Minor accidents like cuts and wounds in the fingers are common contributing to the lower productivity. The hand operated *Aonla* pricking machine is economical, safe, portable and efficient alternative.

MATERIALS AND METHODS

The *aonla* fruits were obtained from the CCS Haryana Agricultural University farm, Hisar. The study was

undertaken in Hisar on a sample of 4 healthy subjects ranging from 25-35 years of age. *Aonlas* were kept in simple water without any additive for 2 days before the pricking and the variety chosen was *Banarasi*. The quantity of *aonla* taken for the purpose of pricking was 24 Kg. Pricking activity was conducted by these selected subjects by different methods viz. by using fork, pricking tool and hand operated *Aonla* pricking machine. The ambient conditions were recorded by using different equipment and were maintained in order to study the ergonomics and to evaluate the performance. Various parameters viz. activity profile, physiological workload and biochemical stress were analyzed to carry out the ergonomic assessment of *aonla* pricking. Activity profile consisting of tools used method of pricking and output parameters were recorded.

Measurement of Heart Rate and Blood Pressure

Heart rate is the number of ventricular beats per minute (bpm). The resting, working and average heart rates were measured and analyzed easily without any disturbance to the worker by using electronic heart beat monitor in which the strap was simply tied around the elbow or wrist and was connected with the monitor, which showed the reading. The measurement of blood pressure was also done by the same instrument.

Measurement of Energy Expenditure

The energy expenditure rate (oxygen consumption rate) indicates the level of bodily stress and in relation to heavy work. The oxygen consumption rate was measured with the help of a pulse oximeter. It displayed the percentage of arterial hemoglobin in the oxyhemoglobin configuration. Acceptable normal ranges are from 95 to 100 percent. The energy expenditure during work was calculated by using the regression equation (Dilbaghi *etal*., 2008).

Energy expenditure (kJ/min) = 0.159 * Average working HR (bpm) – 8.72

Measurement of Physiological Cost

Physiological cost involved in this operation was expressed in terms of cardio-respiratory responses of the subjects during work. Heart rate (HR) is an indicator of cardiac stress due to physical workload. Hence, HR was recorded, firstly at rest, and then after every one minute during the experiment till the recovery of the subject. From the values of HR; energy expenditure, total cardiac cost of work (TCCW) and physiological cost of work (PCW) were calculated as following:

CCW = (Average working HR- Average resting HR) x Duration of activity (min.)

CCR= (Average recovery HR – Average resting HR) x Duration of activity (min.)

TCCW= Cardiac cost of work (CCW) + Cardiac cost of recovery (CCR)

Physiological cost of work (PCW) = TCCW/Total duration (Dilbaghi *etal*., 2008)

Measurement of Strength

Grip dynamometer was used to measure grip strength at rest (Sr), and after the work (Sw) separately for the right and left hand. Grip fatigue was calculated as under:

Grip fatigue (%) = $\frac{Sr-Sw}{Sr}\ X\ 100$ (Devangan *etal*., 2008)

Measurement of Load

Load was the prime factor in pricking of *aonla*. Load was measured with the help of a load cell. This load cell was placed in between the pins of hand operated *aonla* pricking machine, when a person pressed the handle of the machine in a reciprocating action, the pins from the top and the bottom of the load cell started compressing it simultaneously and the load applied was shown by the load cell in terms of kilograms.

RESULTS AND DISCUSSIONS

The study was undertaken to evaluate the performance of hand operated *aonla* pricking machine (Figure 1) by comparing it with the traditional methods like fork pricking and pricking done by the use of a specially designed tool considering ergonomic aspect. Each of the 4 subjects pricked 2 kg of *aonla* by all the three methods and their various anthropometric data (Table 1) was collected along with the time taken by each individual to finish the task. The ambient conditions measured with the help of a thermohygrometer were as follows: Temperature = 19.4°C, Humidity = 51% and Light intensity = 254 lux. The quality of pricking done and the risk factors were also taken into account. The resting, working and average heart rates, blood pressures, time of activity and partial pressure of oxygen (PO_2) levels of different subjects were recorded (Table 2). The performance of hand operated *aonla* pricking machine was then compared with the performance of the other two methods to study the technical feasibility of the aforesaid machine. The average size of the *aonla* taken for pricking was as follows:

Average major axis = 4.22 cm

Average minor axis = 3.15 cm

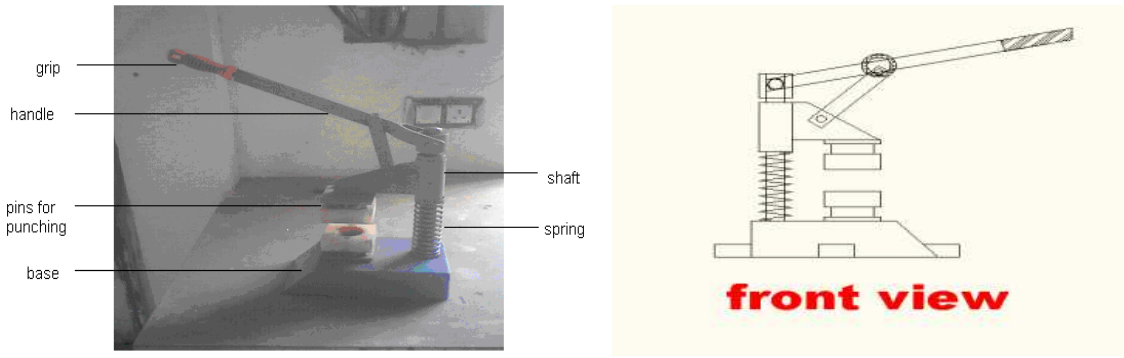

Figure 1: Spring Loaded Hand Operated *aonla* Pricking Machine

From the values of heart rate, energy expenditure was calculated for all 3 methods (Table 3). It came out to be almost equal because of the fact that the pricking activity was not so laborious. Small fluctuations are observed which are due to the difference in the anthropometry of the various subjects.

Table 1: Anthropometric Data of Various Subjects

Anthropometric Measurements	Subject 1	Subject 2	Subject 3	Subject 4
Age	31 years	34 years	27 years	29 years
Weight	68kg	67kg	59kg	64kg
Sex	Female	Male	Male	Female
Vertical reach height(cm)	193	210.8	203.2	195.5
Elbow height(cm)	99.3	112.5	108.9	100.5
Knee height(cm)	44.9	51.3	50	45.4
Shoulder height(cm)	134.6	142.2	137.6	137.1

Table 1: Contd.,				
Total arm length(cm)	63.5	79.5	72.3	68.3
Palm length(cm)	9	9.9	9.3	9.1
Forearm length(cm)	24.8	26.9	25.6	24.6
Height(cm)	157.4	170.1	165.1	160

Table 2: Different Parameters of All Subjects During Pricking

Parameters	Subject 1			Subject 2			Subject 3			Subject 4		
	Fork	Tool	Machine	Fork	Tool	Machine	Fork	Tool	Machine	Fork	Tool	Machine
Avg. working heart rate (bpm)	92	91	92.1	97.1	96.6	96.3	93.1	92.5	90.1	95.4	94.9	95.7
Resting heart rate (bpm)	78	78	78	87	87	87	81	81	81	86	86	86
Blood pressure before pricking	130/87	130/87	130/87	131/89	131/89	131/89	130/92	130/92	130/92	131/92	131/92	131/92
Blood pressure after pricking	132/88	133/88	131/88	134/90	134/91	133/89	133/93	133/93	134/93	132/92	132/93	133/92
PO_2 in blood before activity	98	98	98	98	98	98	97	97	97	97	98	97
PO_2 in blood after activity	98	98	98	99	99	99	97	98	97	98	98	98
Time taken in pricking activity (min)	14.3	14	13.1	16.3	15.5	15.2	12.4	13.4	11.1	14.2	15.1	13.5

From the values of heart rate, cardiac cost of work (Table 4), cardiac cost of recovery (Table 5), total cardiac cost of work (Table 6) and physiological cost of work (Table 7) were calculated. Total cardiac cost of work for hand operated *aonla* pricking machine was less for all the subjects than the other two methods which is because of the convenience and ease of the operation in hand operated *aonla* pricking machine as compared to the other two methods

Table 3: Energy Expenditures of Different Subjects using Different Methods for Pricking

Subjects	Fork (kJ/Min)	Pricking Machine (kJ/Min)	Pricking Tool (kJ/Min)
Subject 1	5.90	6.08	5.59
Subject 2	6.72	6.59	6.48
Subject 3	6.08	5.28	5.98
Subject 4	6.40	6.49	6.33

Table 4: Cardiac Cost of Work for Different Subjects using Different Methods for Pricking

Subjects	Cardiac Cost of Work (Beats)		
	Fork	Pricking Machine	Pricking Tool
Subject 1	203.2	186.8	197.3
Subject 2	168.1	144.4	156.3
Subject 3	153.2	102.9	158.8
Subject 4	135.8	134.8	139.5

Table 5: Cardiac Cost of Recovery for Different Subjects using Different Methods for Pricking

Subjects	Cardiac Cost of Recovery (Beats)		
	Fork	Pricking Machine	Pricking Tool
Subject 1	70.4	54.4	72.0
Subject 2	28.7	29.3	33.6
Subject 3	65.3	48.4	88.1
Subject 4	54.4	40.8	54.5

Table 6: Total Cardiac Cost of Work for Different Subjects using Different Methods for Pricking

Subjects	Total Cardiac Cost of Work (CCW + CCR)		
	Fork	Pricking Machine	Pricking Tool
Subject 1	273.6	241.2	269.3
Subject 2	196.8	173.7	189.9
Subject 3	218.5	151.3	246.9
Subject 4	190.2	175.6	194.0

Grip dynamometer was used to measure grip strength at rest, and after the work separately for the right and left hand. Grip fatigue along with average load applied on the *aonla* for all the 3 methods were calculated (Table 8). Grip fatigue of the subjects in all the three methods of pricking was more in the right hand as compared to the left hand because of the fact that the subjects were not ambidextrous.

Table 7: Physiological Cost of Work for Different Subjects using Different Methods

Subjects	Physiological Cost of Work (B.P.M)		
	Fork	Pricking Machine	Pricking Tool
Subject 1	18.86	18.27	19.09
Subject 2	11.87	11.20	11.94
Subject 3	17.34	13.38	17.89
Subject 4	13.20	12.63	12.84

Table 8: Grip Fatigue for Different Subjects Working by Different Methods

Subjects	Grip Fatigue (%)						Average Load Applied on *aonla* (kg)		
	Fork		Pricking Machine		Pricking Tool				
	Left Hand	Right Hand	Left Hand	Right Hand	Left Hand	Right Hand	Fork	Tool	Machine
Subject 1	1.27	3.13	1.74	4.15	1.19	3.47	2.7	3.2	1.3
Subject 2	1.42	2.83	1.65	3.90	1.47	3.11	2.5	3	1.5
Subject 3	1.38	3.04	2.23	4.21	0.89	2.91	2.5	3.1	1.3
Subject 4	1.66	3.29	2.07	4.18	1.32	2.83	2.6	3.1	1.4

Economic Evaluation

Economic evaluation of hand operated *aonla* pricking machine was undertaken in order to find out the economic feasibility of this machine in rural areas where the traditional methods of pricking i.e. pricking tools and fork, are still predominant

Initial cost of hand operated *aonla* pricking machine = Rs.5000

Fixed Cost

Depreciation [(C-S)/ L*H] = Rs.0.41 per hour or Rs.448.95 per annum

(Assuming that the machine works for 6 hours a day during the months of October to March and the life of the machine is 10 years; as the capital cost and size of the machine was small therefore, we will neglect the cost of housing, taxes, interest and insurance)

Where, C= Capital cost; S= Salvage value (10% of C per annum.)

Variable Cost

Repair & maintenance (5% per annum) = Rs.250

Total cost per year = fixed cost + variable cost = 448.95 + 250 = Rs.699 p.a.

Labour cost (if used) = Rs. 200/day/worker

Suppose 3 people were employed for working,

Total labour cost per month = 200 x 3 x 30 = Rs.18000

Total labour cost per annum = 18000 x 6 = Rs. 108000

The quality of pricking done with the help of hand operated *aonla* pricking machine was better than the traditional methods and was also less time consuming. Moreover the annual cost of pricking barely exceeded Rs.699 (without using labour) which made the machine economically as well as technically feasible for use.

CONCLUSIONS

The capacity of hand operated *aonla* pricking machine was found to be ranging between 15 to 18 kg/hour, which was much more than the traditional methods whose capacity was recorded ranging in between 4 to 7 kg/hour. The average load applied on the *aonla* by the hand operated *aonla* pricking machine was less than the traditional methods therefore the injury of the fruit during pricking in case of hand operated machine was less than the traditional methods. The cost of operation of the machine was slightly more than the traditional methods but the quality and uniformity of pricking was better, and moreover it was safer and quicker method of pricking which made it technically and economically feasible. The total cardiac cost of work and the physiological cost of work in case of hand operated *aonla* pricking machine was less than the traditional methods. The hand operated *aonla* pricking machine is therefore superior in terms of cost, quality and safety to use over traditional methods of pricking.

REFERENCES

1. *Bressel, E., Bressel, M., Heise, G. D.& Marquez, M. (2001). The effect of handgrip position on upper extremity neuromuscular responses to arm cranking exercise. J. of electromyography and kinesiology11(4), 291-298.*
2. *Dilbaghi, M., Gandhi, S. & Bimla (2008). Ergonomic evaluation of improved sickles in wheat harvesting. J. of agricultural engineering45(1), 57-63.*
3. *Dewangan, K. N., Datta, R. K. & Owary, C. (2008). Anthropometric data of female farm workers from north eastern India and design of hand tools of the hilly region. Int. J. of Industrial ergonomics 38(1), 90-100.*